Nantucket Harbor Transects
2002

Prepared for Town of Nantucket
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Temperature and dissolved oxygen transects were conducted in Nantucket Harbor for the year 2002 in order to approximate warming and cooling trends related to scallop reproduction and development. Spawning and feeding are temperature dependent physiological processes of the scallop. Dissolved oxygen is also an important factor in determining the location of scallop populations; based on the level of oxygen content they need in the water in order to survive in certain areas. By monitoring these two factors throughout the harbor it is possible to determine when and where scallops have spawned, when they will begin to feed, i.e. mature, and when they will fall into a period of cessation i.e. stop growing. This data there fore will give us a better understanding of the scallop's life cycle.

Three transects were established across the harbor running north to south in each basin, with three sampling points along each line (Map #1). These transects and points were picked to provide information about bottom characteristics throughout the harbor. They include shallow (3-6'), mid (10-13'), and deep water (22-25') bottom points. These points were sampled from the Harbormaster's boat using a Garmin GPS positioning system, and a Raytheon depth finder while referencing (Map #1). A YSI 85 meter with a 30' cord and weighted probe was used to record temperature and dissolved oxygen at bottom depths at these points. Ten sampling events were conducted in '02 from February to December '02, also included was data taken from harbor sampling on 6/12,10/23, and 11/20 in '02.

The information gathered was compiled, calculated and translated on to four charts (1.3, 1.5, 2.52, and 5.2). These points represent transects 1,2.5, and 3, and are believed to be sufficient because the harbor is for the most part isothermic. This means that there is good mixing of temperature throughout the water column throughout the harbor. There are subtle variations in these three tansects that enable us to determine approximately when spawning events took place in different parts of the harbor. Hypoxic and anoxic levels relating to suitable habitat can also be approximated at specific times and locations. Further optimal feeding periods relating to growth and gonadal development and adversely lengths of cessation can be determined from these transects.

Analysis of this data and interpretation of these graphs show some general trends and a few detailed events throughout the year. Though there is very little stratification there are differences between shallow, mid, and deep-water areas. In general mid and deep-water areas tend to be colder with lower dissolved oxygen levels. Another general trend involves the circulation of the harbor; where by the water in the head of the harbor (Wauwinet) is exchanged at a slower rate than that at the opening (Channel). This was also shown in the Nantucket Harbor Circulation Computer Model provided by ASA (Applied Science Associates). The transects show that because of this type of circulation the head of the harbor warms up faster in the summer, and cools down faster in the winter than Nantucket Sound, and mid harbor areas.

Specific details of this analysis show that spawning occurred in late June between the 6/12* and 7/2 sampling dates. Spawning was induced when temperatures first peaked through the 20 degree Celsius mark in shallow depths (4') of water at the head of the harbor, chart (1.3). This spring set was soon followed by a spawning in the mid harbor areas, chart (2.52). Last to spawn were the scallops in and around the foot of the harbor during mid June; this area covered roughly the Horse Shed, First Point, Hussey Shoal, Monomoy Piers, and The Mooring Field, chart (5.2). This analysis follows with

Belding's findings that mature scallops are induced to spawn by temperatures rapidly rising or falling between 17 and 22 degrees Celsius. Transect data shows that during August temperatures peaked as high as 25.4 C, raising temperatures throughout the harbor to nearly 78 F. Such extremes would not only lead to anoxic events, but would also be extremely stressful on the older scallops. Hypoxic and anoxic dissolved oxygen levels were recorded at the deep transect point at the head of the harbor (1.3) throughout the summer. The mid level depths in the head of the harbor showed hypoxic conditions on 8/2 where at transect (1.5) the d.o. was recorded at 4.42 mg/l. Hypoxic conditions were also seen further west toward the foot of the harbor in Qauise basin during the August sampling event. This level of eutrophication shows a considerable decrease in scallop habitat in the harbor during the summer months. The fall set is believed to have occurred after the 9/5 sampling event as shown in the data, and on all the charts where temperatures began to fall throughout the harbor and in the sound with the onset of fall.

When temperatures rise above 7 degrees Celsius, metabolic processes like feeding and digestion begin within the scallop (Belding). The graphs show that these temperatures had been attained by mid March, from the 3/13, and 4/3 sampling events. Temperatures did not fall below 7 degrees Celsius until after the 11/20 sampling event. It is believed that water temperature did not decrease until mid December, which would have resulted in a nine-month feeding, and growth period. Conversely it may be estimated that for three months there would have been a period of cessation. This period of cessation in the scallop's metabolic processes results in a well defined raised annual growth line on the scallop's shell and is used as the determining factor in the judgment between juveniles and adults (Belding).

This data shows that the spawning period was shorter by one month, and the feeding period was longer by two months this year. This means that scallops in '02 were more active with less time to spawn, assuming that warming and cooling trends last approximately the same amount of time each year. The increased activity and warmer temperatures would only increase the duration and level of stress on the shellfish, and may account for premature death in many cases. The scallops obviously most affected by this would the older ones, the second year classic adults (two growth rings high on the shell), and the third year nub adults (two growth rings, one low, one high on the shell).

Trends observed were that the head of the harbor warms and cools faster than the rest of the harbor as a result of water being trapped there for longer periods of time. Also temperature is inversely proportional to depth and dissolved oxygen, and results in hypoxia and anoxia in certain parts of the harbor at certain times of the year. There were two distinct changes in temperature in the harbor, which would have resulted in two definite spawning events, whose dates can be closely approximated. Cold water temperatures in the harbor would have resulted in three months of cessation for the scallop population, with an activity period of nine months. The temperature changes also help to determine how old scallops would be, based upon when they were spawned, the resultant height of the growth ring, and their level of sexual maturity. Age is shown by the location of the growth ring, or rings on the shell and the coloration of the gonad before and after the last spawning event. Transects will be conducted in 2003 on a smaller scale in order to note continuing trends or yearly changes.

Transects 2002 Nantucket Harbor

Keith Conant, Shellfish Biologist

* Data taken from harbor sampling

1.1 Shallow

	25-Feb.	13-Mar.	3-Apr.	21-May.	6/12*	2-July.	11-July.	2-Aug.	5-Sep.	7-Oct.	10/23*	11/20*	5-Dec.
depth	4.1	3.6	3.5	4.2		3.6	4.9	3.6	4	3.6			3.6
temp	5	5.9	9.1	13		22.8	23.7	24.8	20.7	17.9			0.7
d.o.	10.7	10.7	9.76	8.95		6.45	6.8	6.74	7.08	7.45			12.9

1.3 Deep

	25-Feb.	13-Mar.	3-Apr.	21-May.	6/12*	2-July.	11-July.	2-Aug.	5-Sep.	7-Oct.	10/23*	11/20*	5-Dec.
depth	22.1	21.8	20	24.4	21	23.5	22.2	24	24.3	23	22.8	24	25.2
temp	4.8	5.7	8.7	12.7	17.9	22.7	23.1	24.7	20.5	18.2	12.5	8.9	0.8
d.o.	10.4	7.2	9.95	6	5.6	3	7.1	3.36	5	5.44	8.96	8.9	4.81

1.5 Mid

	25-Feb.	13-Mar.	3-Apr.	21-May.	6/12*	2-July.	11-July.	2-Aug.	5-Sep.	7-Oct.	10/23*	11/20*	5-Dec.
depth	11.2	11.8	12	14		8.4	9.2	12	10.1	8			9
temp	4.6	5.8	8.8	13		22.6	22.9	25.2	20.7	18.2			0.9
d.o.	11.3	10.5	9.9	8.95		6.1	7.33	4.42	6.55	7.41			12.2

2.51 Mid

	25-Feb.	13-Mar.	3-Apr.	21-May.	6/12*	2-July.	11-July.	2-Aug.	5-Sep.	7-Oct.	10/23*	11/20*	5-Dec.
depth	10.8	13.3	7.9	10		10.6	9.8	10	10.6	8			9
temp	4.4	5.5	8.7	12.5		22.3	23	25.4	20.6	18.2			1.5
d.o.	10.9	9.27	10.2	9.23		6.42	7.57	7.27	5.11	7.43			12

2.52 Deep

	25-Feb.	13-Mar.	3-Apr.	21-May.	6/12*	2-July.	11-July.	2-Aug.	5-Sep.	7-Oct.	10/23*	11/20*	5-Dec.
depth	21	26.2	26	28	26	17	26.3	24	25.4	26.5	24	29	28
temp	4.4	5.5	8.8	12.1	18.2	21.9	21.7	25.2	20.7	18.1	12.6	8.9	2.9
d.o.	11.1	9.23	10.2	5.31	7.49	6.19	7.05	6.8	4.91	7.52	9.07	9.64	11.5

2.53 Shallow

	25-Feb.	13-Mar.	3-Apr.	21-May.	6/12*	2-July.	11-July.	2-Aug.	5-Sep.	7-Oct.	10/23*	11/20*	5-Dec.
depth	5.8	4	3	5.2		4.7	5.1	4.4	5.6	6			6
temp	4.5	5.5	8.9	12.7		22.1	23.4	25.3	20.7	18.2			-0.2
d.o.	11.4	9.64	10.3	9.39		7.67	13.7	8.79	7.2	8.1			13.4

5.2 Deep

	25-Feb.	13-Mar.	3-Apr.	21-May.	6/12*	2-July.	11-July.	2-Aug.	5-Sep.	7-Oct.	10/23*	11/20*	5-Dec.
depth	29	23.6	26	26	16.8	26.2	23	20	21.7	24	18.9	18.7	21.6
temp	4.1	5.4	8.5	12.3	17.8	20.9	21.8	24.5	20.9	18.5	12.9	8.9	3.1
d.o.	10.4	9.92	10.2	9.22	6.78	7.2	7.42	7.33	6.9	8.01	8.75	9.25	11.5

5.4 Shallow

	25-Feb.	13-Mar.	3-Apr.	21-May.	6/12*	2-July.	11-July.	2-Aug.	5-Sep.	7-Oct.	10/23*	11/20*	5-Dec.
depth	4.2	4.1	6	3.8		4.1	4	4	4.1	4			4.8
temp	4.1	5.3	8.4	12.4		21.2	22.1	24.3	20.9	18.6			3
d.o.	11.3	10.5	10.6	9.62		7.3	8.38	7.95	7.99	8.32			11.6

5.6 Mid

	25-Feb.	13-Mar.	3-Apr.	21-May.	6/12*	2-July.	11-July.	2-Aug.	5-Sep.	7-Oct.	10/23*	11/20*	5-Dec.
depth	13.5	8.6	10	10.7		10.1	11.5	10	11.3	12			12
temp	4	5.3	9	12.4		21.3	21.9	23.9	20.9	18.6			2.7
d.o.	11.4	10.5	9.61	9.45		7.3	7.84	6.86	7.82	7.49			11.6